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Description

SYSTEM AND METHOD FOR A FLAMELESS TRACER/MARKER UTILIZING AN ELECTRONIC LIGHT SOURCE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit under 35 USC 119(e) of provisional application 60/320042, filed March 24, 2003, the entire file wrapper contents of which provisional application are herein incorporated by reference as though fully set forth at length.

FEDERAL RESEARCH STATEMENT

[0002] The inventions described herein may be manufactured, used, and licensed by, or for the U.S. Government for U.S. Government purposes.

BACKGROUND OF INVENTION

[0003] *FIELD OF THE INVENTION*

[0004] This invention relates to munitions employed for training and tactical purposes. More particularly, the present in-

vention relates to a tracer for small, medium and large caliber ammunition, mortar and canon caliber ammunition employing an electronic light source capable of providing flight path trace and site identification.

[0005] *BACKGROUND OF THE INVENTION*

[0006] In both military and non-military organizations, training and tactical exercises commonly employ materials capable of providing a visible trace of a projectile's trajectory after firing from a weapon. This visible trace, or tracer, assures that the projectile has been delivered to its desired target site and that its flight path has been traced from gun tube to target.

[0007] One requirement for the tracer is that an observer should be able to see the tracer either during daylight or night-time. Current tracer technology employs pyrotechnic compositions comprised of pyrotechnic materials that burn and create light. These pyrotechnic compositions are typically loaded into the back end of the projectile, or round. After the projectile is fired from the weapon, the tracer ignites and burns creating a visible light that can be seen as the projectile travels to its target. The observer and/or gunner can consequently see the trace of the projectile flight. If necessary, the observer can then adjust the

weapon so that the next round fired can impact the desired target location. Exemplary pyrotechnic compositions suitable for such purpose are strontium nitrate, magnesium powder, potassium nitrate, barium nitrate, and the like.

[0008] Although such conventional methods have met with some degree of success, workers in the art have encountered certain difficulties. For example, tracer ammunition has frequently resulted in fires on training ranges that have been attributed to energetic material tracers contacting and burning surrounding brush and other ground material. These fires incur additional costs in extinguishing the fires and also interrupt training exercise. Consequently, training exercises may be extended to replace time lost, thereby incurring additional expense. Furthermore, materials used in pyrotechnic tracers are environmentally unfriendly. These materials often pose environmental hazards to training areas as a result of toxic emissions into the atmosphere and such materials leaching into ground water. Still further, tracer materials commonly in use are impact and pressure sensitive. Since projectiles housing the pyrotechnic materials may be transported, the nature and explosive properties of these pyrotechnic materials

add significant costs and danger to personnel.

[0009] Tracers have also utilized chemiluminescent materials. The chemiluminescent materials are similar to conventional chemiluminescents, however, certain ingredients and manufacturing techniques were developed to obtain the capability of long duration (up to several hours for marker application) and high light intensity tracing and marking capability. The oxalate component employed is in a liquid (contained in glass vials) and in a powdered form; when mixed with a liquid peroxide, a non-toxic slurry is formed that is non-flammable and biodegradable. In addition, the chemiluminescent can provide a visible or IR light source. The IR light source provides a stealth capability such that only soldiers with IR vision equipment can see the trace or mark.

[0010] Although this technology has proven to be useful, it would be desirable to present additional improvements. A tracer and marker design that does not involve a flaming tracer, an environmentally damaging chemical, the loading of chemicals into a projectile, or the transporting and handling of projectiles housing chemicals, pyrotechnics, or energetic materials would be desirable. Furthermore, a light source that can be adjusted to last for several sec-

onds up to several months would be desirable. The need for such a system has heretofore remained unsatisfied.

SUMMARY OF INVENTION

[0011] The present invention satisfies this need, and presents a system and an associated method (collectively referred to herein as "the system" or "the present system") for utilizing an electronic light source in a flameless tracer and/or marker for use in small, medium and large caliber ammunition. The present system may be positioned in various locations and combinations of locations on a projectile (e.g., front, back, side, etc.) and inside a translucent or transparent projectile to enhance visibility of the projectile during flight and/or deliver a mark on a target. The goal of the present system is to provide a light source on or inside the projectile that is visible to an observer at various viewing angles throughout the projectile flight without the environmental or safety issues presented by conventional tracers. Depending on the need, the light source of the present system could mark a target with trace of flight, mark a target without trace of flight, or provide trace without mark. These options are controlled by the projectile design.

[0012] The present system is environmentally friendly and in-

volves no chemical mixtures. The present system is not flammable or explosive, instead relying on a light that is powered by electricity. The present system comprises a light source, an optional driver circuit, and a power supply. These components are equivalent in price to the pyrotechnic materials used in present flame tracers. The present system is easily configurable to fit a variety of both tactical and training rounds. After assembly, the present system is encapsulated in glass or clear plastic or epoxy if needed to G-harden the present system, enabling the present system to sustain the large loads and stresses induced by gun launch. All components used in the present system are available in electronic stores except for microminiaturized or MEMs components that are currently being developed for the U.S. Government.

[0013] The present system may comprise a variety of light sources such as, for example, lasers, high output light-emitting diodes (LEDs), strobe lights, laser diodes, photo diodes, etc. The present system is capable of flashing the light sources at a variety of frequencies (e.g., 5 Hz, 20 Hz, etc.) to further attract the human eye. The light sources may be purchased at electronic stores at designated frequency, intensity, and wavelengths. Furthermore, the

present system presents the substantial benefit of being able to project light at various wavelengths outside the visible spectrum. Some light sources that may be used by the present system are available, for example, in infrared (IR), ultraviolet (UV), and visible wavelengths and at various frequencies. Consequently, the present system comprising light sources such as IR or UV could be used in tactical situations such that the tracer and/or marker is visible only to personnel using IR night vision, UV detectors, etc. Furthermore, the present system can provide a light source in the visible wavelengths, allowing troops to see colors that have specific tactical meaning. In addition, the present system can be configured to provide a tracer with no mark, a trace with mark, or no trace but a mark on a target. The configuration is determined by the need of the soldier using the item.

[0014] The light created by the light source may be focused or directed in a manner to enhance its visibility to the observer. For example, a plastic or composite reflective cap, mirror(s), or reflector(s) in the path of a light beam may intermittently cast a bright beam to wider angles. Furthermore, the light source may be placed in different locations on the projectile to enhance visibility. These and other

methods of enhancing the visibility of the light generated by the present system may be used singly or in combination in the present system.

[0015] The present system comprises a power source used to provide power for the tracer or marker light. This power source may comprise, for example, capacitors, batteries, mechanical generators, electric gel, or fuel cells. Exemplary mechanical generators suitable for use in the present system comprise vibrating impellors, stator impellors, or flywheels. These and other power sources may be used singly or in combination in the present system.

[0016] In an alternative embodiment, components of the present system available in industry may be miniaturized, micro-miniaturized, or made into a MEMs to form a miniature or MEMs flashing light or non-flashing light. These miniature, microminiaturized, or MEMs lights may be delivered by a projectile to mark targets, personnel, or areas. Exemplary delivery projectiles comprise small, medium or large caliber projectiles, i.e., 60, 81 or 120mm mortars, 20, 40, 90 mm grenades, 105 or 120mm tank or 105 to 155mm artillery ammunition. In addition, if the projectile is made of a transparent or translucent material these lights would provide a trace of the flight path of the projectile. The

projectile may carry and deliver to a target dozens, hundreds, or thousands of miniature flashing lights in a sticky gelatin-like substance. Upon impact, the sticky gelatin substance would splatter on the target and disperse the miniature, microminiaturized, or MEMs flashing light around the target area. The size of the payload and amount of dispersion may be controlled depending on the application. These miniature or MEMS lights may cast visible light, infrared light, UV, or combinations of spectrums to suit the application.

[0017] The miniature, microminiaturized, or MEMS lights in a gelatin-like substance may be used, for example, to permit identification of impact areas. In addition, missiles and smart munitions that contain infrared or UV seeking sensors can home in on a target marked by miniature or MEMS lights and thereby guide a munition to its target. Furthermore, miniature light sources emitting either visible, infrared, UV light, or a combination of these spectrums may be delivered by projectiles to illuminate, for example, caves, equipment, booby traps, enemy vehicles, projectile impact areas, personnel, etc. In addition, infrared or UV light sources provided by the miniature or MEMS lights would allow personnel to look into a cave

with infrared or UV (night vision) detection devices to a much greater depth than previously possible. Current night detection devices are only capable of detecting temperature differences. Booby traps that are deeply embedded in a cave and at the same temperature as the cave would not be detected by night vision devices unless marked, for example, with a miniaturized flashing light. Further, flashing miniature or MEMS lights may be used to direct a unit in battle to concentrate their projectiles into a marked area. This area would be marked by visible and/or UV, and/or infrared miniature, microminiaturized, or MEMS light when dispersed from a projectile. This visual signal is an effective method to get the attention of soldiers during battle because battle noise interferes with communication. In this manner, the fighting unit is more efficient in defeating an enemy.

[0018] As mentioned, a variety of electronic light sources may be used in the present system to provide a trace to target of the projectile flight and/or a mark of the target. Exemplary light sources comprise lasers, high output light-emitting diodes (LEDs), strobe lights, etc.

[0019] For trace-only applications of the present system, a device to produce light is constructed of laser diodes, LEDs,

strobes, etc. and fit into the rear or side of the projectile. The device may be attached to a setback, setforward, or spin activated battery that activates only when these forces are achieved. Setback is the force exerted on a projectile as the projectile begins to move when being fired from a gun. Setback forces are typically extremely high and have values from 10 to 70,000 G's. Setforward forces are usually 1-20% of setback. Spin typically exceeds 60 revolutions/minute depending on the ammunition; therefore spin can typically be initiated only when fired. An alternate embodiment would use a small battery in a sleeve as a power source and activation switch. The battery slides in place when setback forces occur and switches on the light device. The device provides high intensity light while the projectile travels downrange to provide a trace to target.

[0020] In addition, the battery may contain the chemicals that provide electric power in separate compartments separated by a membrane. When the projectile is fired the membrane breaks and the projectile spin mixes the chemicals causing the power to be available to the light source.

[0021] Present systems that provide trace and mark may utilize a

setback battery or battery in a sleeve combined with the light-emitting source (i.e. LED, miniaturized LED, or MEMS device with LED) and combined with an optional flashing unit. These devices are placed inside a transparent or translucent projectile. Only the part of the projectile that contains the devices needs to be transparent or translucent. A sticky substance (i.e. silicon gel) in a container such as glass, plastic vials, plastic bags, etc. are contained in the projectile to help the devices stick to and mark a target. The light-emitting devices are also enclosed in the container. The glass vials may be held apart by a spider to keep the glass vials from hitting each other and breaking. The spider is secured to the projectile so that the vials do not break. If the devices are placed in a plastic bag and the sticky substance is placed in a plastic bag then the bags are designed to be extremely tough and will only break when encountering the setback, setforward, or spin force. These bags are added directly to the projectile until the projectile is full.

[0022] Upon setback, the setback battery activates and powers the high intensity light-emitting devices. If a battery in a sleeve is utilized, the battery slides into position after setback and powers the light-emitting devices. The vials or

bags shatter and the light-emitting devices mix with the sticky materials. The light-emitting devices continue to emit a high intensity light during the projectile flight and provide a trace to target. Upon projectile impact with the target the plastic projectile breaks and scatters the sticky light-emitting devices on the target, marking the target. The sticky material cushions and protects the light-emitting devices as they scatter on the target and helps them to adhere to the target. The miniaturized or MEMs LEDs, strobes, laser diodes, etc. are manufactured to be rugged and to survive the impact at target. The high intensity devices can provide a visible, IR, and/or UV high intensity light mark on target. Depending on the battery, the light can be set to last for a few seconds or up to a month. The battery does not have to be part of the marking device when using photo diodes since an energy source such as a laser directed at the photo diodes from a distance will light up the photo diodes.

[0023] To provide a mark only, the plastic projectile may be made of an opaque substance that does not allow the light to pass.

Brief Description of Drawings

[0024] The various features of the present invention and the

manner of attaining them will be described in greater detail with reference to the following description, claims, and drawings, wherein reference numerals are reused, where appropriate, to indicate a correspondence between the referenced items, and wherein:

[0025] FIG. 1 is comprised of FIGS. 1A, 1B, 1C, and 1D and represents a cutaway view of a large caliber tank projectile showing various locations of electronic tracers in an electronic light source system assembly and an optional transparent or translucent plastic or composite cap that protects the electronic tracer and helps scatter the light;

[0026] FIG. 2 is comprised of FIGS. 2A and 2B and represents a cutaway view of a small, medium, and large caliber Kinetic Energy (KE) projectile showing optional locations for the electronic tracer, the location of an optional transparent or translucent plastic or composite cap, and the electronic tracer assembly attached to the side and rear of the projectile with the protective cap attached;

[0027] FIG. 3 is comprised of FIGS. 3A and 3B and represents a cutaway view of a mortar projectile showing optional locations for the electronic tracer, the location of an optional transparent or translucent plastic or composite cap, and the electronic tracer assembly attached to the side and

rear of the projectile with the optional protective cap attached;

[0028] FIG. 4 is comprised of FIGS. 4A and 4B and represents a cutaway view of a 40mm projectile 400 showing the location for the electronic tracer, the location of an optional transparent or translucent plastic or composite cap, and the electronic tracer assembly attached to the rear of the 40mm projectile with the optional protective cap attached;

[0029] FIG. 5 is comprised of FIGS. 5A and 5B and represents a cutaway view of an artillery projectile 500 showing optional locations for the electronic tracer and the location of an optional transparent or translucent plastic or composite cap, and the electronic tracer assembly attached to the side and rear of the projectile with the optional protective cap attached;

[0030] FIG. 6 is a cutaway view of a setback battery or battery in a sleeve design that may be used as part of the electronic tracer assembly of FIGS. 1, 2, 3, 4, and 5;

[0031] FIG. 7 is a process flow chart illustrating a method of operation of a setback-activated battery of FIG. 6 for the electronic tracer of FIGS. 1, 2, 3, 4, and 5;

[0032] FIG. 8 is a cutaway view of the electronic tracer attached to the rear of the projectile representative of the elec-

tronic tracers of FIGS. 1, 2, 3, 4, and 5;

[0033] FIG. 9 is a cutaway view of an electronic tracer attached to the side of the projectile representative of the electronic tracers of FIGS. 1, 2, 3, and 5;

[0034] FIG. 10 is a cutaway view of the optional transparent or translucent plastic or composite cap;

[0035] FIG. 11 is comprised of FIGS. 11A, 11B, and 11C and represents a cutaway view of a marker light source device, light source devices suspended in a sticky medium in a bag, and light source devices suspended in a sticky medium in glass vials;

[0036] FIG. 12 is comprised of FIGS. 12A, 12B, and 12C and represents a cutaway view of a mortar projectile that contains the miniature, microminiaturized, or MEMS electronic light source markers in a sticky medium;

[0037] FIG. 13 is comprised of FIGS. 13A, 13B, and 13C and represents a cutaway view of a 40mm projectile, which contains the miniature, microminiaturized, or MEMS electronic light source markers in a sticky medium; and

[0038] FIG. 14 is comprised of FIGS. 14A, 14B, and 14C and represents a cutaway view of a tank or artillery projectile, which contains the miniature, microminiaturized, or MEMS electronic light source markers in a sticky medium.

Detailed Description

[0039] FIG. 1 (FIGS. 1A, 1B, 1C, 1C) is a cutaway view of a large caliber tank projectile 100 showing various locations for an electronic tracer assembly. The electronic tracer assembly that attaches to the side of the projectile is an electronic tracer 110A. The electronic tracer assembly that attaches to the rear of the projectile is an electronic tracer 120A.

[0040] A plastic or composite protective cap 130A attaches to the rear of the projectile. Protective cap 130A scatters the light from the electronic tracer 120A, enhancing observation of the projectile in flight. Protective cap 130A may also contain miniature reflectors or mirrors (not shown) to help scatter the light emitted by the electronic tracer 120A.

[0041] FIG. 1A is an exploded view of the projectile 100 showing where the electronic tracers 110A, 120A would be attached. Either electronic tracer 120A or electronic tracer 110A may be attached to projectile 100. Alternatively, both electronic tracer 120A and electronic tracer 110A may be attached to projectile 100 for optimal visibility by an observer of the in-flight projectile 100.

[0042] FIG. 1B shows the electronic tracer 120A and protective

cap 130A attached to the rear of the projectile 100.

[0043] FIG. 1C shows the electronic tracer 110A attached to the side of the projectile 100.

[0044] FIG. 1D shows the electronic tracer 120A and protective cap 130A attached to the rear of projectile 100 and electronic tracer 110A attached to the side of the projectile 100. Electronic tracer 120A and protective cap 130A may be attached to projectile 100 using either epoxy or a threaded connection (not shown). Electronic tracer 110A may be attached to projectile 100 using epoxy (not shown).

[0045] FIG. 2 (FIGS. 2A, 2B) is a cut-away view of a small, medium, and large caliber in-flight KE projectile 200 (projectile 200). FIG. 2A is a cut-away exploded view of projectile 200. An electronic tracer 120B may be attached on the rear of projectile 200. An electronic tracer 110B may be attached to the side of projectile 200.

[0046] An optional protective cap 130B made of transparent or translucent plastic or composite material may be attached to the electronic tracer 120B. The protective cap 130B keeps gun gases and contaminates away from the electronic tracer 120B. The protective cap 130B helps to reflect the light in many directions, making it easier for an

observer to see the projectile 200 in flight. The protective cap 130B may also comprise small mirrors or reflectors (not shown) to help reflect the light.

[0047] FIG. 2B is a cutaway view showing the electronic tracer 120B attached to the rear of projectile 200 and the electronic tracer 110B attached to the side of projectile 200. Either electronic tracer 120B or electronic tracer 110B may be attached to projectile 200. Alternatively, both electronic tracer 120B and electronic tracer 110B may be attached to projectile 200 for optimal visibility of the in-flight projectile 200 by an observer. Electronic tracer 120B and protective cap 130B may be attached to projectile 200 using either epoxy or a threaded connection (not shown). Electronic tracer 110B may be attached to projectile 200 using epoxy (not shown).

[0048] FIG. 3 (FIGS. 3A, 3B) is a cut-away view of a mortar projectile 300 (projectile 300) utilizing electronic tracer 120C and electronic tracer 110C. FIG. 3A is a cut-away exploded view of a mortar projectile 300 (projectile 300). Electronic tracer 120C may be attached on the rear of projectile 300. Electronic tracer 110C may be attached to the side of projectile 300. An optional protective cap 130C made of transparent or translucent plastic or composite

material may be attached to the electronic tracer 120C.

[0049] The protective cap 130C keeps gun gases and contaminates away from the electronic tracer 120C. The protective cap 130C helps to reflect the light in many directions, making it easier for an observer to see the projectile 300 in flight. The protective cap 130C may also contain small mirrors or reflectors (not shown) to help reflect the light. FIG. 3B is a cutaway view showing the electronic tracer 120C attached to the rear of projectile 300 and electronic tracer 110C attached to the side of projectile 300.

[0050] Either electronic tracer 120C or electronic tracer 110C may be attached to projectile 300. Alternatively, both electronic tracer 120C and electronic tracer 110C may be attached to projectile 300 for optimal visibility of the in-flight projectile 300 by an observer. Electronic tracer 120C and protective cap 130C may be attached to projectile 300 using either epoxy or threaded connection (not shown). Electronic tracer 110C may be attached to projectile 300 using epoxy (not shown).

[0051] FIG. 4 (FIGS. 4A, 4B) is a diagram of a 40 mm projectile 400 (projectile 400) utilizing electronic tracer 120D. 4A is a cut-away exploded view of projectile 400. Electronic tracer 120D may be attached on the rear of projectile 400.

An optional protective cap 130D made of transparent or translucent plastic or composite material may be attached to the electronic tracer 120D.

[0052] The protective cap 130D keeps gun gases and contaminates away from the electronic tracer 120D. The protective cap 130D helps to reflect the light in many directions, making it easier for an observer to see the projectile 400 in flight. The protective cap 130D may also contain small mirrors or reflectors (not shown) to help reflect the light. FIG. 4B is a cutaway view showing the electronic tracer 120D attached to the rear of projectile 400 and optional protective cap 130D attached to electronic tracer 120D. The electronic tracer 120D and protective cap 130D may be attached to projectile 400 using either epoxy or threaded connection (not shown).

[0053] FIG. 5A (FIGS. 5A, 5B) is a cut-away view an artillery projectile 500 (projectile 500) utilizing electronic tracer 120E and electronic tracer 110E. FIG. 5A is a cut-away exploded view of projectile 500. Electronic tracer 120E may be attached on the rear of projectile 500. Electronic tracer 110E may be attached to the side of projectile 500.

[0054] An optional protective cap 130E made of transparent or translucent plastic or composite material may be attached

to the electronic tracer 120E. The protective cap 130E keeps gun gases and contaminates away from the electronic tracer 120E. The protective cap 130E helps to reflect the light in many directions, making it easier for an observer to see the projectile 500 in flight.

[0055] The protective cap 130E may also contain small mirrors or reflectors (not shown) to help reflect the light. FIG. 5B is a cutaway view showing the electronic tracer 120E attached to the rear of projectile 500 and electronic tracer 110E attached to the side of projectile 500. Either the electronic tracer 120E or the electronic tracer 110E may be attached to projectile 500. Alternately, both the electronic tracer 120E and the electronic tracer 110E may be attached to projectile 500 for optimal visibility of the in-flight projectile 500 by an observer. Electronic tracer 120E and protective cap 130E may be attached using either epoxy or threaded connection (not shown). Electronic tracer 110E may be attached to projectile 500 using epoxy (not shown).

[0056] FIG. 6 is a cutaway view of a setback-activated battery 600 (also known as battery in a sleeve 600). The setback-activated battery 600 is readily available on the commercial market. Battery 610 is held in a sleeve 605. Upon set-

back, set-forward, or spin, the battery 610 moves until slots 615, 620 engage tabs 645, 650 and lock the battery 610 in place.

[0057] The terminals 625, 630 contact the terminals 635, 640 providing power to terminals 635, 640. The electronic tracers 120A, 120B, 120C, 120D, 120E and electronic tracers 110A, 110B, 110C, 110E of FIGS. 1, 2, 3, 4, and 5 (FIGS. 1 through 5) that are connected to setback-activated battery 600 are now activated and produce the light needed. Setback force is the force applied to the projectile upon shot start. Set-forward force is the force that is exerted on the projectile after it leaves the gun.

[0058] Spin is imparted to the projectile either by rifling in the gun tube or by the cant angle on the fins of the projectile. The setback and set-forward forces and spin imparted to projectiles 100, 200, 300, 400, 500 of FIGS. 1 through 5 are substantial; consequently, battery 610 will not lock into place and provide power to terminals 635, 640 under normal or rough handling of the projectiles of FIGS. 1 through 5. Setback-activated battery 600 will only activate when the projectile is fired from the gun.

[0059] Battery 610 may also comprise chemicals common in industry that are separated by a membrane (not shown).

Upon gun launch, the membrane ruptures and the chemicals mix providing electric power as needed.

[0060] FIG. 7 illustrates a method 700 of operation of the electronic tracers 120A, 120B, 120C, 120D, 120E and electronic tracers 110A, 110B, 110C, 110E of FIGS. 1 through 5 utilizing a setback-activated battery 600 as an exemplary power source. Gun launch occurs at block 701. During high G forces in the acceleration (setback), slight deceleration (set-forward), or spin, the chemicals mix in the battery 610 providing electrical power. In block 702, the battery slides over tabs 645, 650.

[0061] When the tabs 645, 650 line up with the recesses 615, 620 of chemical battery 610, the battery 610 locks into position as shown in block 703. The battery terminals 625, 630 of battery 610 contact the terminals 635, 640 of the sleeve 605 (block 704). In block 705, power is now supplied to the light producing source such as LEDs, strobes, laser diodes, etc. or an optional driver circuit. The light source of the electronic tracers 120A, 120B, 120C, 120D, 120E or electronic tracers 110A, 100B, 110C, 110E now emit light and the flight of the projectile can be seen.

[0062] An optional driver circuit is commonly available. The optional driver circuit is only needed if adjustability of the

intensity and flashing frequency of the electronic tracers 120A, 120B, 120C, 120D, 120E or electronic tracers 110A, 100B, 110C, 110E is desired. Off the shelf commercial light producing LEDs, strobes, laser diodes, etc. have flashers and intensity controlling devices already built into their miniaturized products that produce UV, visible, and IR light at any wavelength needed.

[0063] These light producing items are readily added to the electronic tracers 120A, 120B, 120C, 120D, 120E and electronic tracers 110A, 100B, 110C, 110E at extremely low cost. Building or adding the driver circuit is optional since it adds to the cost of the electronic tracer.

[0064] FIG. 8 is a cutaway view of an electronic tracer 120 representative of the electronic tracers 120A, 120B, 120C, 120D, 120E attached to the rear of projectiles 100, 200, 300, 400, 500 of FIGS. 1 through 5. The electronic tracer 120 comprises light-emitting sources 122 such as LEDs, strobes, laser diodes, etc. that are attached to housing 121A. Electronic tracer 120 comprises a setback-activated battery 600A similar to setback-activated battery 600 sized to fit this application.

[0065] The optional driver circuit may be placed inside of housing 121A. The light-emitting source 122 may be attached

to the housing 121A with epoxy. The leads (not shown) in the back of light-emitting source 122 contact the terminals 635, 640 of setback-activated battery 600. After gun launch, power flows from the terminals 635, 640 to the light-emitting source 122. The light-emitting source 122 begins operation and emits light, providing a trace to target from the rear of the projectiles 100, 200, 300, 400, 500 of FIGS. 1 through 5.

[0066] FIG. 9 is a cutaway view of the electronic tracer 110 representative of electronic tracers 110A, 110B, 110C, 110E that is attached to the side of the projectiles 100, 200, 300, 500 of FIGS. 1, 2, 3, and 5. The electronic tracer 110 comprises light-emitting sources 122 such as LEDs, strobes, laser diodes, etc. that are attached to housing 121B. Electronic tracer 110 comprises a setback-activated battery 600B similar to setback-activated battery 600 sized to fit this application.

[0067] The optional driver circuit may be placed inside of housing 121B if needed. The light-emitting source 110 may be attached to the housing 121B with epoxy. The leads (not shown) in the back of light-emitting source contact the terminals 635, 640 of setback-activated battery 600. After gun launch, power flows from terminals 635, 640 to the

light-emitting source 110. The light-emitting source 122 begins operation and emits light, providing a trace to target from the side of the projectiles 100, 200, 300, 500 of FIGS. 1, 2, 3, and 5.

[0068] FIG. 10 is a cutaway view of the protective cap 130, representative of protective caps 130A, 130B, 130C, 130D, 130E. This optional protective cap 130 may be made of transparent or translucent plastic or composite. The protective cap 130 is attached to the electronic tracer 120 with epoxy or a threaded connection (not shown). Miniaturized mirrors or reflectors (not shown) may be attached to or be part of the protective cap 130 to help reflect or disperse the light in many directions to help an observer see the projectile 100, 200, 300, 400, 500 in flight. The protective cap 130 helps to protect the electronic tracers 120 from propellant gases and contaminates.

[0069] Another embodiment of a light-emitting source marks targets by giving off UV, visible, and/or IR light. FIG. 11 (FIGS. 11A, 11B, 11C) is a diagram illustrating the use of a light-emitting source 122 in a target marking application. FIG. 11A is a cutaway view of a light-emitting source 122 such as an LED, strobe, laser diodes, etc. that may be used to mark a target. Light-emitting source 122 com-

prises a light-emitting device 123 and setback-activated battery 600C sized to fit the application.

[0070] Both light-emitting device 123 and setback-activated battery 600C are commonly available in electronic stores and in industry in miniaturized versions. The U. S. government is currently investing in microminiaturization of these devices. FIG. 11B is a cutaway view of package 1210 comprising the light-emitting sources 122 surrounded by a sticky substance 1212 such as silicone liquid or gel (commonly available in industry).

[0071] Package 1210 is made of a plastic or composite bag 1211 that holds the light-emitting sources 122 and sticky liquid or gel 1212. The package 1210 may be placed into projectiles 100, 200, 300, 400, 500 and delivered to the intended target that will be marked. If the projectile 100, 200, 300, 400, 500 is made of transparent or translucent material, the light-emitting sources 122 will also provide a trace to target.

[0072] FIG. 11C is a cutaway view of an alternate containment system for the light-emitting source 122, package 1220. The light-emitting source 122 is placed in sealed glass vials 1222 (glass vials are commonly manufactured in industry by melting the ends of glass tubes) and surrounded

by sticky liquid or gel 1212. The vials are held apart by a plastic or composite spider 1221.

[0073] The amount of light-emitting sources 122 that can be placed in package 1210 or package 1220 will depend on size of the projectile and therefore the size of the package 1210 or package 1220. In addition, the size of light-emitting source 122 will determine how many light-emitting sources 122 can be placed in the package. Industry manufactured off-the-shelf light-emitting devices are currently approximately 1/8 to ½inch in length.

[0074] Microminiaturized and MEMS light-emitting sources 122 are currently being researched and developed for the U. S. government and will be several orders of magnitude smaller. Eventually the microminiaturized MEMS sources 122 will be smaller than the eye can see. Therefore dozens, hundreds and even thousands of the light-emitting sources 122 will be able to be contained in package 1210 or package 1220.

[0075] FIG. 12 (FIGS. 12A, 12B, 12C) is a cutaway view of a mortar projectile (mortar 1300). FIG. 12 A is a cutaway view of mortar 1300 containing packages 1210 which is surrounded by sticky material 1212. FIG. 12B is a cutaway view of a mortar 1300 containing package 1220 that is

surrounded by sticky material 1212. A side view of the plastic or composite spider 1221 is shown. The glass vials 1222 side into and are held apart by holes in the spider.

[0076] FIG. 12C is an exploded cutaway view before assembly of a mortar 1300 that can carry packages 1210 or package 1220 to the target to be marked. The mortar 1300 comprises a steel or aluminum or plastic or composite back end 1315, a transparent or translucent plastic or composite body 1310, and a plastic or composite nose 1305. Packages 1210 or package 1220 can be placed into the body 1310 and then epoxied or threaded (not shown) to the back end 1315.

[0077] The sticky material 1212 can then be added to the projectile at the open end on the top of body 1310. The cap 1305 is then epoxied or threaded (not shown) to the body 1310 to complete the assembly of mortar 1300. If the user of the mortar 1300 wants a mark and trace capability then body 1310 and nose 1305 should be transparent or translucent. A transparent or translucent back end 1315 is optional and would enhance the observation of the tracer. If the user wants marking with no trace then the back end 1315, body 1310, and nose 1305 should be made of opaque material or painted so that light does not come

through the projectile during flight.

[0078] Upon gun launch, the packages 1210 or package 1220 rupture or shatter allowing the contents comprising the light-emitting sources 122 and sticky material 1212 to mix. The light-emitting sources 122 are provided power by setback-activated battery 600C and begin operation, emitting light. If the projectile is transparent or translucent, a trace of the flight is seen by an observer due to the high intensity light from the light-emitting sources 122. If the project is opaque, there is no trace.

[0079] Upon impact of mortar 1300 with the target, the plastic or composite of the mortar 1300 shatters and deposits the light-emitting sources 122 covered with the sticky material 1212 onto the target. The high intensity light from the light-emitting sources 122 now marks the target in UV and/or visible, and/or IR light. Soldiers with night vision devices can now see the UV and IR light. Missiles and smart projectiles equipped with sensors and seekers set to detect the wavelengths of the light-emitting sources 122 can now see the marked target and travel to it.

[0080] FIG. 13 (FIGS. 13A, 13B, 13C) is a cutaway view of a 40mm projectile 1400 (projectile 1400). FIG. 13A is a cutaway view of projectile 1400 containing package 1210 that is

surrounded by sticky material 1212. FIG. 13B is a cutaway view of projectile 1400 containing package 1220 that is surrounded by sticky material 1212.

[0081] FIG. 13C is an exploded cutaway view before assembly of projectile 1400 that can carry the packages 1210 or package 1220 to the target to be marked. The projectile 1400 comprises a steel, aluminum, plastic, or composite back end 1420 and a transparent or translucent plastic or composite windshield 1410.

[0082] The packages 1210 or package 1220 and sticky material 1212 may be placed into the windshield 1410 and then epoxied or threaded (not shown) to the back end 1420. If the user of the projectile 1400 wants a mark and trace capability then windshield 1410 may to be transparent or translucent. If the user wants marking with no trace then the windshield 1410 should be made of opaque material or painted so that light does not come through the projectile during flight.

[0083] Upon gun launch, the containers 1210 or 1220 rupture or shatter allowing the contents 122 and 1212 to mix. The light-emitting sources are provided power by setback-activated battery 600C and begin operation, emitting light. If the projectile is transparent or translucent, a trace

of the flight is seen by an observer due to the high intensity light from the light-emitting sources 122.

[0084] If the project is opaque there is no trace. Upon impact of projectile 1400 with the target, the plastic or composite of the projectile 1400 shatters and deposits the light-emitting sources 122 covered with the sticky material 1212 onto the target. The high intensity light from the light-emitting sources 122 now marks the target in UV, visible, and/or IR light. Soldiers with night vision devices can now see the UV and IR light. Missiles and smart projectiles equipped with sensors and seekers set to detect the wavelengths of the light-emitting sources 122 can now see the marked target and travel to it.

[0085] FIG. 14 (FIGS. 14A, 14B, 14C) is a cutaway view of a tank or artillery projectile 1500 (projectile 1500). FIG. 14A is a cutaway view of projectile 1500 containing package 1210 that is surrounded by sticky material 1212. FIG. 14B is a cutaway view of projectile 1500 containing package 1220 that is surrounded by sticky material 1212.

[0086] FIG. 14C is an exploded cutaway view before assembly of projectile 1500 that can carry the packages 1210 and package 1220 to the target to be marked. The projectile 1500 comprises a steel, aluminum, plastic, or composite

back end 1530, a transparent or translucent plastic or composite body 1520 and a plastic or composite nose 1510 (nose 1510). The package 1210 or package 1220 may be placed into the body 1520 and then epoxied or threaded (not shown) to the back end 1530.

[0087] The sticky material 1212 can then be added to the projectile at the open end on the top of body 1520. The nose 1510 is then epoxied or threaded (not shown) to the body 1520 to complete the assembly of projectile 1500. If the user of the projectile 1500 wants a mark and trace capability then back end 1530 and body 1520 should be transparent or translucent. If the user wants marking with no trace then the back end 1530, body 1520 and nose 1510 should be made of opaque material or painted so that light does not come through the projectile during flight.

[0088] Upon gun launch, the packages 1210 or package 1220 rupture or shatter allowing the light-emitting source 122 and sticky material 1212 to mix. The light-emitting sources 122 are provided power by setback-activated battery 600C and being operation, emitting light. If the projectile 1500 is transparent or translucent, a trace of the flight is seen by an observer due to the high intensity

light from the light-emitting sources 122.

[0089] If the projectile 1500 is opaque, there is no trace. Upon impact of projectile 1500 with the target, the plastic or composite of the projectile 1500 shatters and deposits the light-emitting sources 122 covered with the sticky material 1212 onto the target. The high intensity light from the light-emitting sources 122 now marks the target in UV, and/or visible, and/or IR light. Soldiers with night vision devices can now see the UV and/or IR light. Missiles and smart projectiles equipped with sensors and seekers set to detect the wavelengths of the light-emitting sources 122 can now see the marked target and travel to it.

[0090] All drawings are illustrative in nature and do not depict the actual size or scale of the objects shown. It is to be understood that the specific embodiments of the invention that have been described are merely illustrative of certain applications of the principle of the present invention. Numerous modifications may be made to system and method for a flameless tracer utilizing electronic light source invention described herein without departing from the spirit and scope of the present invention.